IMAQ™

IMAQ PCI/PXI™-1422 User Manual

High-Quality Digital Image Acquisition Board for PCI, PXI, and CompactPCI Chassis

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Compliance

FCC/Canada Radio Frequency Interference Compliance*

Determining FCC Class

The Federal Communications Commission (FCC) has rules to protect wireless communications from interference. The FCC places digital electronics into two classes. These classes are known as Class A (for use in industrial-commercial locations only) or Class B (for use in residential or commercial locations). Depending on where it is operated, this product could be subject to restrictions in the FCC rules. (In Canada, the Department of Communications (DOC), of Industry Canada, regulates wireless interference in much the same way.)

Digital electronics emit weak signals during normal operation that can affect radio, television, or other wireless products. By examining the product you purchased, you can determine the FCC Class and therefore which of the two FCC/DOC Warnings apply in the following sections. (Some products may not be labeled at all for FCC; if so, the reader should then assume these are Class A devices.)

FCC Class A products only display a simple warning statement of one paragraph in length regarding interference and undesired operation. Most of our products are FCC Class A. The FCC rules have restrictions regarding the locations where FCC Class A products can be operated.

FCC Class B products display either a FCC ID code, starting with the letters **EXN**, or the FCC Class B compliance mark that appears as shown here on the right.

Consult the FCC web site `http://www.fcc.gov` for more information.

FCC/DOC Warnings

This equipment generates and uses radio frequency energy and, if not installed and used in strict accordance with the instructions in this manual and the CE Mark Declaration of Conformity**, may cause interference to radio and television reception. Classification requirements are the same for the Federal Communications Commission (FCC) and the Canadian Department of Communications (DOC).

Changes or modifications not expressly approved by National Instruments could void the user's authority to operate the equipment under the FCC Rules.

Class A

Federal Communications Commission

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

Canadian Department of Communications

This Class A digital apparatus meets all requirements of the Canadian Interference-Causing Equipment Regulations.

Cet appareil numérique de la classe A respecte toutes les exigences du Règlement sur le matériel brouilleur du Canada.

Class B

Federal Communications Commission

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Canadian Department of Communications

This Class B digital apparatus meets all requirements of the Canadian Interference-Causing Equipment Regulations.

Cet appareil numérique de la classe B respecte toutes les exigences du Règlement sur le matériel brouilleur du Canada.

European Union - Compliance to EEC Directives

Readers in the EU/EEC/EEA must refer to the Manufacturer's Declaration of Conformity (DoC) for information** pertaining to the CE Mark compliance scheme. The Manufacturer includes a DoC for most every hardware product except for those bought for OEMs, if also available from an original manufacturer that also markets in the EU, or where compliance is not required as for electrically benign apparatus or cables.

To obtain the DoC for this product, click **Declaration of Conformity** at `ni.com/hardref.nsf/`. This website lists the DoCs by product family. Select the appropriate product family, followed by your product, and a link to the DoC (in Adobe Acrobat format) appears. Click the Acrobat icon to download or read the DoC.

* Certain exemptions may apply in the USA, see FCC Rules §15.103 **Exempted devices**, and §15.105(c). Also available in sections of CFR 47.

**The CE Mark Declaration of Conformity will contain important supplementary information and instructions for the user or installer.

Conventions

The following conventions are used in this manual:

<>	Angle brackets that contain numbers separated by an ellipsis represent a range of values associated with a bit or signal name—for example, DBIO<3..0>.
♦	The ♦ symbol indicates that the following text applies only to a specific product, a specific operating system, or a specific software version.
	This icon denotes a note, which alerts you to important information.
	This icon denotes a caution, which advises you of precautions to take to avoid injury, data loss, or a system crash.
	This icon denotes a warning, which advises you of precautions to take to avoid being electrically shocked.
italic	Italic text denotes variables, emphasis, a cross reference, or an introduction to a key concept. This font also denotes text that is a placeholder for a word or value that you must supply.
`monospace`	Text in this font denotes text or characters that you should enter from the keyboard, sections of code, programming examples, and syntax examples. This font is also used for the proper names of disk drives, paths, directories, programs, subprograms, subroutines, device names, functions, operations, variables, filenames and extensions, and code excerpts.

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1 Introduction

This chapter describes the IMAQ PCI/PXI-1422 image acquisition device and your software programming choices.

About the PCI/PXI-1422

The IMAQ PCI/PXI-1422 is a highly flexible image acquisition device for PCI, PXI, and CompactPCI chassis that supports a diverse range of digital cameras from several different camera companies. The PCI/PXI-1422 acquires digital images in real time and can store the images in onboard frame memory or transfer them directly to system memory. The device can capture up to 16 bits of data at a time at clock speeds up to 40 MHz.

The PCI/PXI-1422 is simple to configure and is factory calibrated so that you can easily install the device and begin acquiring images. The PCI/PXI-1422 ships with NI-IMAQ, the National Instruments complete IMAQ driver software you can use to directly control the PCI/PXI-1422 and other National Instruments IMAQ hardware products. Using NI-IMAQ, you can quickly and easily start your applications without having to program the device at the register level.

Featuring a high-speed data flow path, the PCI/PXI-1422 is ideal for both industrial and scientific environments. As a stand-alone device, the PCI/PXI-1422 supports up to 16 bits of differential video data, four general-purpose control lines that can be configured to generate precise timing signals to control digital camera acquisition, and four external input/output (I/O) lines that you can use as triggers or as high-speed digital I/O lines. If you require more advanced triggering or digital I/O lines (either digital or analog), you can use the PCI/PXI-1422 and NI-IMAQ with the National Instruments data acquisition (DAQ) product line.

A common problem with other image acquisition devices is that you cannot easily synchronize several functions to a common trigger or timing event. The PCI/PXI-1422 uses its Real-Time System Integration (RTSI) bus to solve this problem. The RTSI bus consists of the National Instruments RTSI bus interface and ribbon cable to route additional timing and trigger signals

between the PCI/PXI-1422 and up to four National Instruments DAQ or IMAQ devices in your computer. The RTSI bus can even synchronize multiple IMAQ hardware captures.

For more detailed specifications on the PCI/PXI-1422, see Appendix A, *Specifications*.

Using PXI with CompactPCI

Using PXI-compatible products with standard CompactPCI products is an important feature provided by the *PXI Specification*, Revision 1.0. If you use a PXI-compatible plug-in device in a standard CompactPCI chassis, you will be unable to use PXI-specific functions, but you can still use the basic plug-in device functions. For example, the RTSI bus on your PXI-1422 device is available in a PXI chassis, but not in a CompactPCI chassis.

The CompactPCI specification permits vendors to develop sub-buses that coexist with the basic PCI interface on the CompactPCI bus. Compatible operation is not guaranteed between CompactPCI devices with different sub-buses or between CompactPCI devices with sub-buses and PXI. The standard implementation for CompactPCI does not include these sub-buses. The PXI-1422 device works in any standard CompactPCI chassis adhering to the *PICMG 2.0 R2.1 CompactPCI* core specification using the 64-bit definition for J2.

PXI-specific features are implemented on the J2 connector of the CompactPCI bus. Table 1-1 lists the J2 pins the PXI-1422 device uses. The PXI device is compatible with any CompactPCI chassis with a sub-bus that does not drive these lines. Even if the sub-bus is capable of driving these lines, the PXI device is still compatible as long as those pins on the sub-bus are disabled by default and are never enabled. Damage may result if these lines are driven by the sub-bus.

Table 1-1. Pins Used by the PXI-1422 Device

PXI-1422 Signal	PXI Pin Name	PXI J2 Pin Number
RTSI Trigger (0..6)	PXI Trigger (0..6)	B16, A16, A17, A18, B18, C18, E18

Software Programming Choices

Using NI-IMAQ, the National Instruments image acquisition driver software, you can program your IMAQ device to acquire and save images. You can use NI-IMAQ with other National Instruments software for a complete image acquisition and analysis solution, as shown in Figure 1. NI-IMAQ works with LabVIEW and LabWindows/CVI, as well as conventional programming languages. National Instruments IMAQ Vision adds powerful image processing and analysis to these programming environments. You can also use IMAQ Vision Builder to quickly and easily prototype your IMAQ image analysis applications.

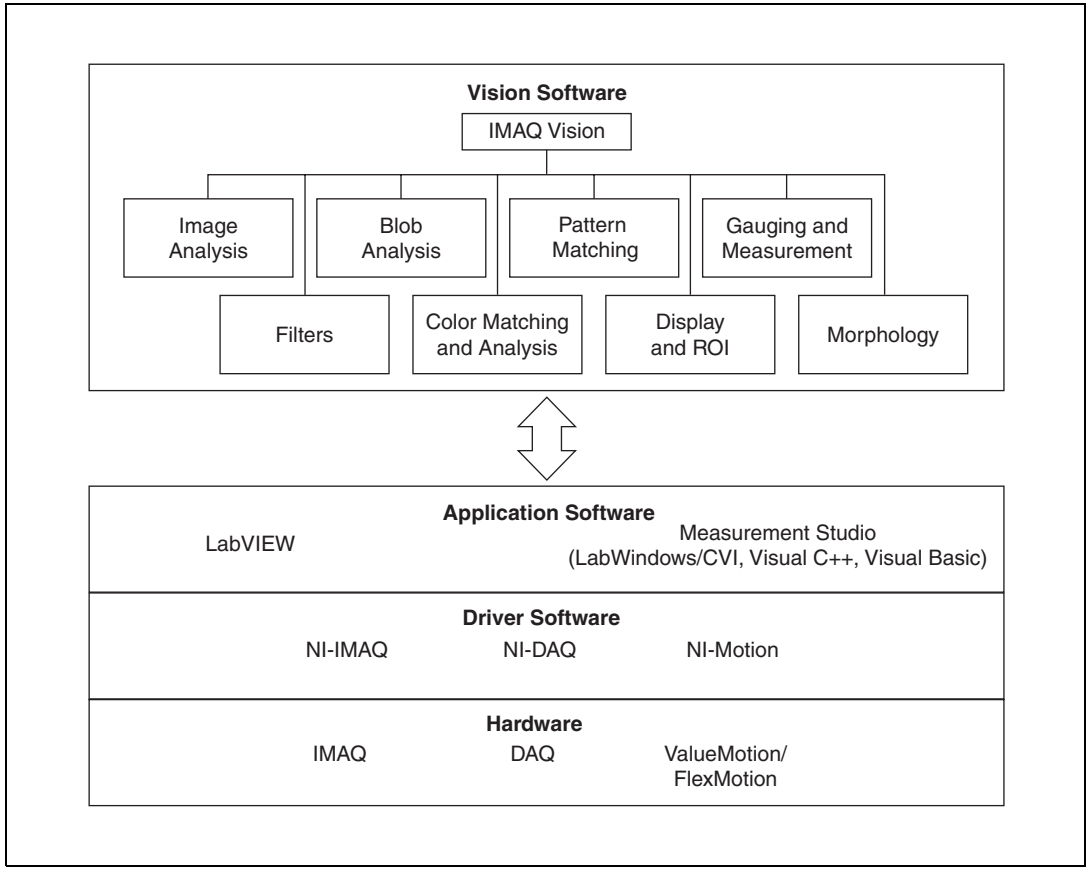

Figure 1-1. The Relationship between the Programming Environment, NI-IMAQ, and Your Hardware

NI-IMAQ Driver Software

The NI-IMAQ driver software is included with your IMAQ device. NI-IMAQ has an extensive library of functions that you can call from your application programming environment. These functions include routines for video configuration, image acquisition (continuous and single-shot), memory buffer allocation, trigger control, and board configuration, as shown in Figure 1-2.

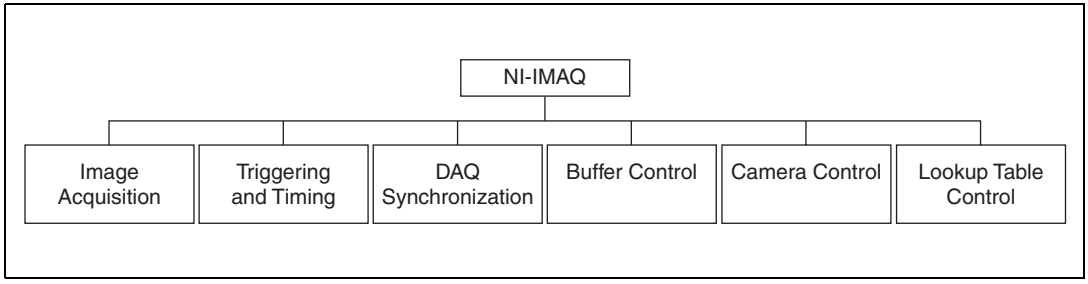

Figure 1-2. NI-IMAQ Functions

The NI-IMAQ driver software performs all functions required for acquiring and saving images. The NI-IMAQ software does not perform image analysis. For image analysis functionality, refer to the *National Instruments IMAQ Vision* section in this chapter.

For maximum flexibility and performance, NI-IMAQ has both high-level and low-level functions. Examples of high-level functions include the functions that acquire images in single-shot or continuous mode. An example of a low-level function is configuring an image sequence since it requires advanced understanding of the IMAQ device and image acquisition.

NI-IMAQ internally resolves many of the complex issues between the computer and your IMAQ device, such as programming interrupts and DMA controllers.

NI-IMAQ is also the interface path between the IMAQ device and LabVIEW, LabWindows/CVI, or a conventional programming environment. The NI-IMAQ software kit includes a series of libraries for image acquisition for LabVIEW and Measurement Studio, which contains libraries for LabWindows/CVI, Visual C++, and Visual Basic. These libraries are functionally equivalent to the NI-IMAQ software.

National Instruments IMAQ Vision

IMAQ Vision is an image acquisition, processing, and analysis library of more than 200 functions for grayscale, color and binary image display, image processing, pattern matching, shape matching, blob analysis, gauging, and measurement.

You can use IMAQ Vision functions directly or in combination for unique image processing. With IMAQ Vision you can acquire, display, manipulate, and store images as well as perform image analysis, processing, and interpretation. Using IMAQ Vision, an imaging novice or expert can perform graphical programming of the most basic or complicated image applications without knowledge of any algorithm implementations.

IMAQ Vision is available for LabVIEW and Measurement Studio, which includes support for LabWindows/CVI, Visual C++, and Visual Basic.

IMAQ Vision Builder

IMAQ Vision Builder is an interactive prototyping tool for machine vision and scientific imaging developers. With IMAQ Vision Builder, you can prototype vision software quickly or test how various vision image processing functions work.

As shown in Figure 1-3, IMAQ Vision Builder generates a Builder file, which is a text description that contains a recipe of the machine vision and image processing functions. This Builder file provides a guide you can use for developing applications with IMAQ Vision in LabVIEW or Measurement Studio.

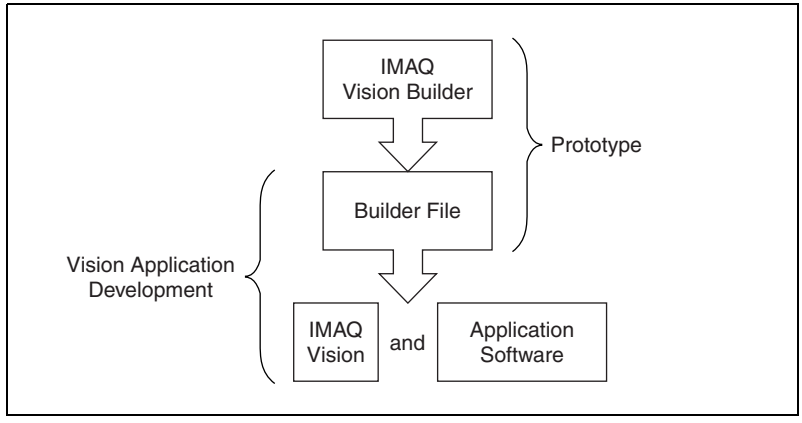

Figure 1-3. IMAQ Vision Builder and Application Development Tools

Integration with DAQ

Any platform that supports NI-IMAQ also supports NI-DAQ and a variety of National Instruments DAQ boards, so your IMAQ device and NI-IMAQ development can integrate with National Instruments DAQ products.

Vision and Motion

With National Instruments IMAQ hardware and IMAQ Vision pattern matching software, you can quickly and accurately locate objects in instances where objects vary in size, orientation, focus, and even when the part is poorly illuminated. Use National Instruments high-performance stepper and servo motion control products with pattern matching software in inspection and guidance applications such as locating alignment markers on semiconductor wafers, guiding robotic arms, inspecting the quality of manufactured parts, and locating cells.

2

Installation

This chapter lists items you need to get started acquiring images with your IMAQ device. This chapter also describes optional equipment and custom cables for your IMAQ device and explains how to unpack, configure, and install your IMAQ device.

What You Need to Get Started

To set up and use your PCI/PXI-1422, you need the following items:

- ❑ One of the following 1422 devices:
  - PCI-1422
  - PXI-1422
- ❑ *Getting Started with Your IMAQ System*
- ❑ *IMAQ PCI/PXI-1422 User Manual*
- ❑ *NI-IMAQ Release Notes (*2.5 or higher)
- ❑ NI-IMAQ 2.5 or higher for Windows 2000/NT/Me/9*x* and documentation
- ❑ Optional software packages and documentation:
  - IMAQ Vision for LabVIEW or Measurement Studio (LabWindows/CVI, Visual C++, Visual Basic)
  - IMAQ Vision Builder
  - LabVIEW
  - Measurement Studio (LabWindows/CVI, Tools for Visual Basic)
- ❑ Your Pentium-based PCI computer running Windows 2000/NT/Me/ or 9*x*.
- ❑ IMAQ D100 series camera cables, depending on your camera
- ❑ A digital video camera

Optional Equipment

National Instruments offers a variety of products for use with your PCI/PXI-1422, including the following cables and other National Instruments products:

- Cables to connect your digital camera to the PCI/PXI-1422
- IMAQ D2504 video cable for access to trigger lines
- A four-pod BNC cable that routes trigger signals to a BNC connector block (IMAQ D2504)
- RTSI bus cables for connecting the PCI/PXI-1422 to other IMAQ or DAQ hardware
- Other National Instruments DAQ devices for enhanced triggering, timing, and input/output

For more specific information about these products, refer to the National Instruments catalog or Web site, or call the office nearest you.

How to Set up Your IMAQ System

Use Figure 2-1 as a guide while you install your software and hardware, configure your hardware, and begin using NI-IMAQ in your application programs.

Follow the instructions in the *Getting Started with Your IMAQ System* document to install your NI-IMAQ software and IMAQ hardware.

If you access the NI-IMAQ device drivers through LabVIEW, read the *NI-IMAQ Release Notes* and the *NI-IMAQ User Manual* to help you get started.

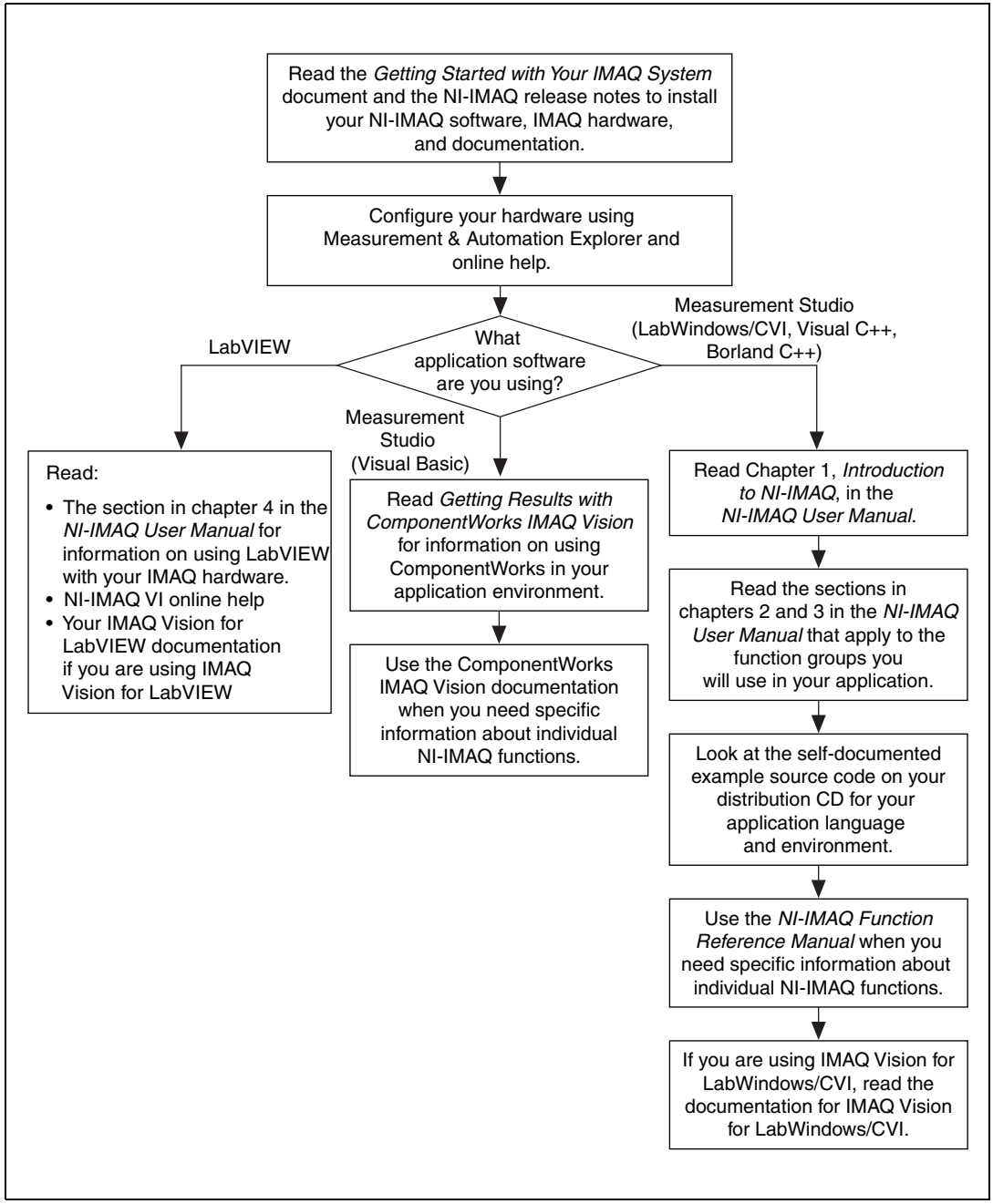
Read the *Getting Started with Your IMAQ System* document and the NI-IMAQ release notes to install your NI-IMAQ software, IMAQ hardware, and documentation.
Configure your hardware using Measurement & Automation Explorer and online help.
What application software are you using?
LabVIEW
Measurement Studio (Visual Basic)
Measurement Studio (LabWindows/CVI, Visual C++, Borland C++)
Read:
• The section in chapter 4 in the *NI-IMAQ User Manual* for information on using LabVIEW with your IMAQ hardware.
• NI-IMAQ VI online help
• Your IMAQ Vision for LabVIEW documentation if you are using IMAQ Vision for LabVIEW
Read *Getting Results with ComponentWorks IMAQ Vision* for information on using ComponentWorks in your application environment.
Use the ComponentWorks IMAQ Vision documentation when you need specific information about individual NI-IMAQ functions.
Read Chapter 1, *Introduction to NI-IMAQ*, in the *NI-IMAQ User Manual*.
Read the sections in chapters 2 and 3 in the *NI-IMAQ User Manual* that apply to the function groups you will use in your application.
Look at the self-documented example source code on your distribution CD for your application language and environment.
Use the *NI-IMAQ Function Reference Manual* when you need specific information about individual NI-IMAQ functions.
If you are using IMAQ Vision for LabWindows/CVI, read the documentation for IMAQ Vision for LabWindows/CVI.

Figure 2-1. How to Set up Your IMAQ System

Safety Information

Cautions *The following paragraphs contain important safety information you must follow when installing and operating the device.*

Do *not* operate the device in a manner not specified in the documentation. Misuse of the device may result in a hazard and may compromise the safety protection built into the device. If the device is damaged, turn it off and do not use it until service-trained personnel can check its safety. If necessary, return the device to National Instruments for repair.

Keep away from live circuits. Do not remove equipment covers or shields unless you are trained to do so. If signal wires are connected to the device, hazardous voltages can exist even when the equipment is turned off. To avoid a shock hazard, do not perform procedures involving cover or shield removal unless you are qualified to do so. Disconnect all field power prior to removing covers or shields.

If the device is rated for use with hazardous voltages (>30 Vrms, 42.4 Vpk, or 60 Vdc), it may require a safety earth-ground connection wire. See the device specifications for maximum voltage ratings.

Because of the danger of introducing additional hazards, do not install unauthorized parts or modify the device. Use the device only with the chassis, modules, accessories, and cables specified in the installation instructions. All covers and filler panels must be installed while operating the device.

Do *not* operate the device in an explosive atmosphere or where flammable gases or fumes may be present. Operate the device only at or below the pollution degree stated in the specifications. Pollution consists of any foreign matter—solid, liquid, or gas—that may reduce dielectric strength or surface resistivity. Pollution degrees are listed below.

- Pollution Degree 1—No pollution or only dry, nonconductive pollution occurs. The pollution has no effect.
- Pollution Degree 2—Normally only nonconductive pollution occurs. Occasionally, nonconductive pollution becomes conductive because of condensation.
- Pollution Degree 3—Conductive pollution or dry, nonconductive pollution occurs. Nonconductive pollution becomes conductive because of condensation.

Insulate signal connections for the maximum voltage for which the device is rated. Do *not* exceed the maximum ratings for the device. Remove power from signal lines before connection to or disconnection from the device.

Operate this device only at or below the installation category stated in the specifications. Installation categories are listed below.

- Installation Category IV—for measurements performed at the source of the low-voltage installation. Examples include electricity meters, measurements on primary overcurrent protection devices, and ripple-control units.
- Installation Category III —for measurements performed in the building installation. Examples include measurements on distribution boards, circuit-breakers, wiring (including cables), bus bars, junction boxes, switches, socket outlets in the fixed installation, equipment for industrial use, and some other types of equipment, such as stationary motors permanently connected to the fixed installation.
- Installation Category II —for measurements performed on circuits directly connected to the low-voltage installation. Examples include measurements on household appliances, portable tools, and other similar equipment.
- Installation Category I—for measurements performed on circuits not directly connected to mains. Examples include measurements on circuits not derived from mains, and specially-protected (internal) mains-derived circuits.

Clean the device and accessories by brushing off light dust with a soft, nonmetallic brush. Remove other contaminants with a stiff, nonmetallic brush. The unit must be completely dry and free from contaminants before returning it to service.

Unpacking

Your PCI/PXI-1422 is shipped in an antistatic package to prevent electrostatic damage to the board. Electrostatic discharge can damage several components on the board. To avoid such damage in handling the board, take the following precautions:

- Ground yourself via a grounding strap or by holding a grounded object.
- Touch the antistatic package to a metal part of your computer chassis before removing the board from the package.

- Remove the board from the package and inspect the board for loose components or any other signs of damage. Notify National Instruments if the board appears damaged in any way. Do *not* install a damaged board in your computer.
- *Never* touch the exposed pins of connectors.

Installation

Note You must install the NI-IMAQ driver software before installing your 1422 device. For information on how to install NI-IMAQ, see the *Getting Started with Your IMAQ System* document and your *NI-IMAQ Release Notes*.

You can install the PCI-1422 in any available PCI expansion slot in your computer. However, to achieve the best noise performance, leave as much room as possible between the PCI-1422 and other boards and hardware.

Note Follow the guidelines in your computer documentation for installing plug-in hardware.

1. Turn off and unplug your computer.

Warning To protect both yourself and the computer from electrical hazards, the computer should remain off until you finish installing the PCI-1422.

2. Follow the electrostatic discharge guidelines in the *Unpacking* section of this chapter.
3. Remove the cover of your computer.
4. Make sure there are no lighted LEDs on your motherboard. If any are lit, wait until they go out before continuing your installation.
5. Touch the metal part of the power supply case inside the computer to discharge any static electricity that might be on your clothes or body.
6. Locate the metal bracket that covers the cut-out in the back panel of the chassis for the slot you have selected. Remove and save the bracket-retaining screw and the bracket cover.
7. Line up the PCI-1422 with the 100-pin SCSI-type connector near the cut-out on the back panel. Slowly push down on the top of the PCI-1422 until its card-edge connector is resting on the expansion slot receptacle. Using slow, evenly distributed pressure, press the PCI-1422 straight down until it seats in the expansion slot.

8. Reinstall the bracket-retaining screw to secure the PCI-1422 to the back panel rail.
9. Visually verify the installation.
10. Replace the computer cover.

Your PCI-1422 is now installed.

- PXI-1422

You can install a PXI-1422 in any available 5 V peripheral slot in your PXI or CompactPCI chassis.

Note The PXI-1422 has connections to several reserved lines on the CompactPCI J2 connector. Before installing a PXI-1422 in a CompactPCI system that uses J2 connector lines for purposes other than PXI, see *Using PXI with CompactPCI*, in Chapter 1, *Introduction*, of this manual.

1. Turn off and unplug your PXI or CompactPCI chassis.
2. Choose an unused PXI or CompactPCI 5 V peripheral slot. Install the PXI-1422 in a slot that supports bus arbitration or bus-master cards. PXI-compliant chassis must have bus arbitration for all slots.
3. Remove the filler panel for the peripheral slot you have chosen.
4. Touch a metal part on your chassis to discharge any static electricity that might be on your clothes or body.
5. Insert the PXI-1422 in the selected 5 V slot. Use the injector/ejector handle to fully inject the device into place.
6. Screw the front panel of the PXI-1422 to the front panel mounting rails of the PXI or CompactPCI chassis.
7. Visually verify the installation.
8. Plug in and turn on the PXI or CompactPCI chassis.

Your PXI-1422 is now installed.

3

Hardware Overview

This chapter presents an overview of the hardware functions on your PCI/PXI-1422 board and explains the operation of each functional unit making up the PCI/PXI-1422.

Functional Overview

The PCI/PXI-1422 features a flexible, high-speed data path optimized for the reception and formatting of video data from digital cameras.

The block diagram in Figure 3-1 illustrates the key functional components of the PCI/PXI-1422.

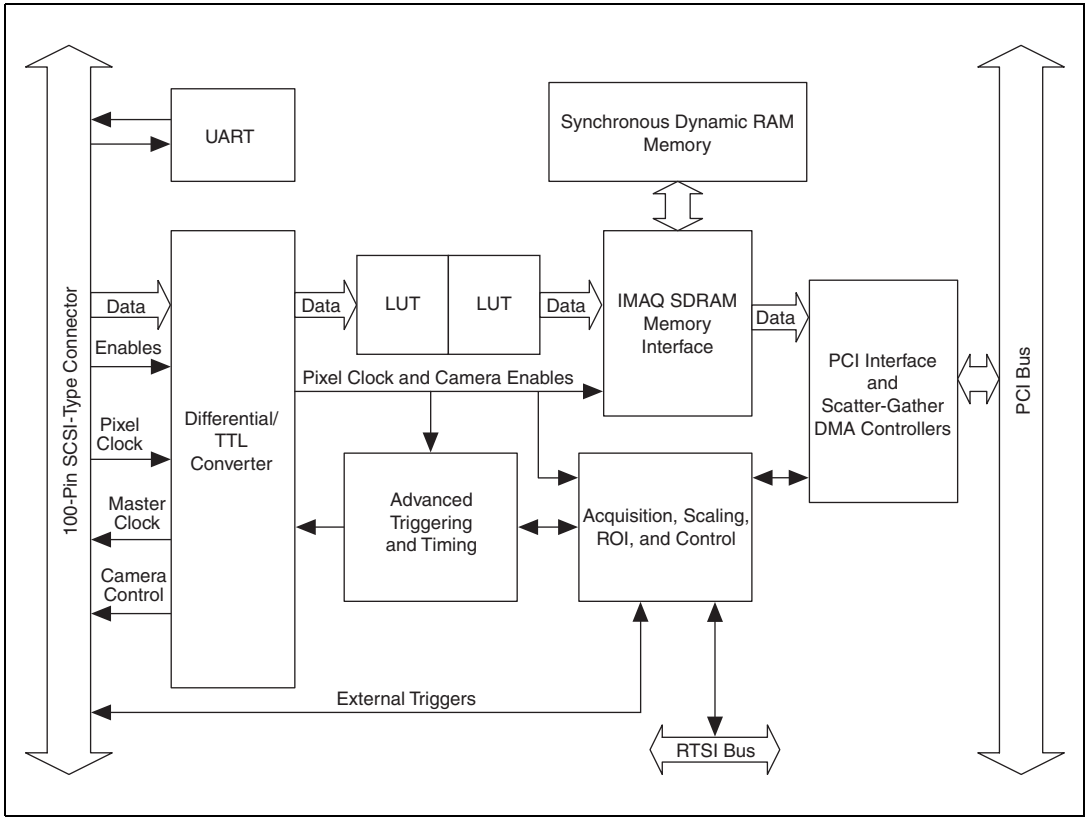

Figure 3-1. PCI/PXI-1422 Block Diagram

Differential/TTL Level Converters

The PCI/PXI-1422 can drive and receive either TTL or differential-level camera control signals. These signal levels can be controlled independently for the control and enable lines on the 100-pin SCSI-type connector.

LUTs

The PCI/PXI-1422 uses a 64 KB-by-16 bit lookup table (LUT) that you can use for two 256 B-by-8 bit LUT operations or one 64 KB-by-16 bit lookup table. You can configure this LUT to perform simple imaging operations such as contrast enhancement, data inversion, gamma manipulation, or other nonlinear transfer functions.

Multiple-Tap Data Formatter

Many digital cameras transfer multiple channels, or taps, of data simultaneously to increase the frame rate of the camera. However, the data in each tap may not be transferred in the traditional top-left to bottom-right direction. Also, the taps may not transfer data in similar directions.

The multiple-tap data formatting circuitry on the PCI/PXI-1422 can reorder the data from up to two 8-bit taps. The data from each tap can be independently scanned either from left-to-right or right-to-left and top-to-bottom or bottom-to-top.

SDRAM

The PCI/PXI-1422 comes with 32 MB of onboard high-speed synchronous dynamic RAM (SDRAM).

Advanced Clock Generation

The advanced clock generation circuitry on the PCI/PXI-1422 generates frequencies from 500 kHz to 40 MHz for digital cameras that require an external clock.

RS-232 Serial Interface (UART)

You can use the RS-232 serial interface on the 100-pin SCSI-type connector to control digital cameras that also have a serial interface for camera control and configuration.

Note The RS-232 serial interface is accessible only via the NI-IMAQ driver software.

Trigger Control and Mapping Circuitry

The trigger control and mapping circuitry routes, monitors, and drives the external and RTSI bus trigger lines. You can configure each of these lines to start an acquisition on a rising or falling edge. In addition, you can drive each line asserted or unasserted, similar to a digital I/O line. You can also map pulses from the high-speed timing circuitry or many of the PCI/PXI-1422 status signals to these trigger lines. There are four external and four RTSI bus triggers. You can program each of these triggers in polarity and direction.

High-Speed Timing

The high-speed timing circuitry on the PCI/PXI-1422, built from high-speed counters, allows you to specify or generate precise, real-time control signals. You can map the output of this circuitry to a trigger line to provide accurate pulses and pulse trains.

Acquisition, Scaling, ROI

The acquisition, scaling, and region-of-interest (ROI) circuitry monitors the incoming video signals and routes the active pixels to the multiple-tap data formatter and SDRAM memory. The PCI/PXI-1422 can perform ROI and scaling on all video lines and frames. Pixel and line scaling transfers certain multiples (two, four, or eight) of pixels and lines to onboard memory. In an ROI acquisition, you select an area within the acquisition window to transfer to the PCI bus.

Scatter-Gather DMA Controllers

The PCI/PXI-1422 uses three independent onboard direct memory access (DMA) controllers. The DMA controllers transfer data between the onboard SDRAM memory buffers and the PCI bus. Each of these controllers supports scatter-gather DMA, which allows the DMA controller to reconfigure on-the-fly. Thus, the PCI/PXI-1422 can perform continuous image transfers directly to either contiguous or fragmented memory buffers.

Bus Master PCI Interface

The PCI/PXI-1422 implements the PCI interface with a National Instruments custom application-specific integrated circuit (ASIC), the PCI MITE. The PCI interface can transfer data at a maximum rate of 132 Mbytes/s in bus master mode. The PCI/PXI-1422 can generate 8-, 16-, and 32-bit memory read and write cycles, both single and multiple. In slave mode, the PCI/PXI-1422 is a medium-speed decoder that accepts both memory and configuration cycles. The interface logic ensures that the PCI/PXI-1422 can meet PCI loading, driving, and timing requirements.

Board Configuration NVRAM

The PCI/PXI-1422 contains onboard nonvolatile RAM (NVRAM) that configures all registers on power-up.

Video Acquisition

The PCI/PXI-1422 can acquire digital video in a variety of modes and store the images in the onboard SDRAM memory or transfer the images directly to PCI system memory.

Start Conditions

The PCI/PXI-1422 can start acquisitions in a variety of conditions:

- Software control—The PCI/PXI-1422 supports software control of acquisition start. You can configure the PCI/PXI-1422 to capture a fixed number of fields or frames. This configuration is useful for capturing a single frame or a sequence of frames.
- Trigger control—You can start an acquisition by enabling external or RTSI bus trigger lines. Each of these 11 inputs can start a video acquisition on a rising or falling edge. You can use all four external triggers and up to four RTSI bus triggers simultaneously.
- Delayed acquisition—You can use either software or triggers to start acquisitions instantaneously or after skipping a specific number of images.
- Frame/field selection—With an interlaced camera and the PCI/PXI-1422 in frame mode, you can program the PCI/PXI-1422 to start an acquisition on any odd or even field.

Acquisition Window Control

You can configure numerous parameters on the PCI/PXI-1422 to control the video acquisition window. A brief description of each parameter follows:

- Acquisition window—The PCI/PXI-1422 allows the user to specify a particular region of active pixels and active lines within the incoming video data. The active pixel region selects the starting pixel and number of pixels to be acquired relative to the assertion edge of the horizontal (or line) enable signal from the camera. The active line region selects the starting line and number of lines to be acquired relative to the assertion edge of the vertical (or frame) enable signal.
- Region of interest—The PCI/PXI-1422 uses a second level of active pixel and active line regions for selecting a region of interest. Using the region-of-interest circuitry, the board acquires only a selected subset of the acquisition window.

- Scaling down—The scaling-down circuitry also controls the active acquisition region. The PCI/PXI-1422 can scale down a frame by reducing the number of pixels per line, the number of lines per frame, or both. For active pixel selection, the PCI/PXI-1422 can select every pixel, every other pixel, every fourth pixel, or every eighth pixel. For active line selection, the PCI/PXI-1422 can select every line, every other line, every fourth line, or every eighth line. You can use the scaling-down circuitry in conjunction with the region-of-interest circuitry.
- Interlaced video—The PCI/PXI-1422 supports both interlaced and noninterlaced digital video signals. In interlaced mode, the PCI/PXI-1422 combines the odd and even fields into one contiguous frame for analysis. In noninterlaced mode, each field is treated as an independent frame.

4

Signal Connections

This chapter describes signal connections for the PCI/PXI-1422.

I/O Connector

The PCI/PXI-1422 100-pin SCSI-type connector connects to all digital video data inputs, digital enable inputs, camera control outputs, RS-232 serial interface, and the external trigger signals. To access these connections, you can build your own custom cable or use one of the optional cables from National Instruments.

Note Refer to the National Instruments Web site, `ni.com/imaq`, for the latest information on optional cables and the cameras they support.

Figure 4-1 shows the pinout of the 100-pin SCSI-type connector.

Data0+	1	51	Not Used
Data0–	2	52	Not Used
Data1+	3	53	Not Used
Data1–	4	54	Not Used
Data2+	5	55	Not Used
Data2–	6	56	Not Used
Data3+	7	57	Not Used
Data3–	8	58	Not Used
Data4+	9	59	Not Used
Data4–	10	60	Not Used
Data5+	11	61	Not Used
Data5–	12	62	Not Used
Data6+	13	63	Not Used
Data6–	14	64	Not Used
Data7+	15	65	Not Used
Data7–	16	66	Not Used
Data8+	17	67	Not Used
Data8–	18	68	Not Used
Data9+	19	69	Not Used
Data9–	20	70	Not Used
Data10+	21	71	Not Used
Data10–	22	72	Not Used
Data11+	23	73	Not Used
Data11–	24	74	Not Used
Data12+	25	75	Not Used
Data12–	26	76	Not Used
Data13+	27	77	Not Used
Data13–	28	78	Not Used
Data14+	29	79	Not Used
Data14–	30	80	Not Used
Data15+	31	81	Not Used
Data15–	32	82	Not Used
Control0+	33	83	RI (RS-232)
Control0–	34	84	DTR (RS-232)
Control1+	35	85	DSR (RS-232)
Control1–	36	86	RTS (RS-232)
Control2+	37	87	CTS (RS-232)
Control2–	38	88	DCD (RS-232)
Control3+	39	89	Master Clock1+
Control3–	40	90	Master Clock1–
EnableA+	41	91	Master Clock0+
EnableA–	42	92	Master Clock0–
EnableB+	43	93	SOUT (RS-232)
EnableB–	44	94	SIN (RS-232)
EnableC+	45	95	External Trigger0
EnableC–	46	96	External Trigger1
EnableD+	47	97	External Trigger2
EnableD–	48	98	External Trigger3
Pixel Clock +	49	99	GND
Pixel Clock –	50	100	GND

Figure 4-1. PCI/PXI-1422 Pin Assignments

Signal Description

Table 4-1 describes each signal connection on the 100-pin SCSI-type connector.

Table 4-1. I/O Connector Signals

Signal Name	Description
Control<0..3>±	You can use the control lines on the PCI/PXI-1422 to control digital camera features and timing information. Either static or dynamic, TTL or differential, signals can be generated on these lines to perform such functions as generating integration or shutter pulses to the digital cameras.
CTS	Clear to Send is used for RS-232 connections.
Data<0..15>±	Data<0..15>± allows you to connect data up to 16 bits wide in differential format to the PCI/PXI-1422.
DCD	Data Carrier Detect is used for RS-232 connections.
DSR	Data Set Ready is used for RS-232 connections.
DTR	Data Terminal Ready is used for RS-232 connections.
Enable<A..D>±	The PCI/PXI-1422 can receive any combination of up to four enable signals. These signals can be either TTL or differential. Examples of camera signals which might be connected to these pins are frame enable, line enable, even enable and odd enable. If your camera has a separate field signal, that line should be connected to Enable C.
External Trigger<0..3>	External Trigger<0..3> are TTL I/O lines used to start an acquisition or output to control external events. You can program the triggers to be rising-edge or falling-edge sensitive. You can also program the triggers to be programmatically asserted or unasserted similar to the function of a digital I/O line or to contain internal status signals (by using the onboard events) or specific pulse widths.
GND	GND is a direct connection to digital ground on the PCI/PXI-1422.
Master Clock<0..1>±	You can use these two sets of pins to generate a master clock signal for your digital camera. Possible clock frequencies range from 500 kHz to 40 MHz.
Pixel Clock±	The PCI/PXI-1422 uses the Pixel Clock input as a reference clock to latch the incoming video data.
RI	Ring Indicator is used for RS-232 connections.

Table 4-1. I/O Connector Signals (Continued)

Signal Name	Description
RTS	Request to Send is used for RS-232 connections.
SIN	Serial Data In is used for RS-232 connections.
SOUT	Serial Data Out is used for RS-232 connections.

A

Specifications

This appendix lists the specifications of the IMAQ PCI/PXI-1422. These specifications are typical at 25 °C, unless otherwise stated.

Maximum Working Voltage

Channel to earth	5 V, Installation Category 1 (signal voltage plus common-mode voltage)
Channel to channel	5 V, Installation Category 1 (signal voltage plus common-mode voltage)

External Connections

Trigger sense	TTL
Trigger level	Programmable (rising or falling)
Pixel clock sense	Selectable (TTL or differential)
Pixel clock level	Programmable (rising or falling)
Enable sense	Selectable (TTL or differential)
Enable level	Programmable (rising or falling)
Master clock drive	Selectable (TTL or differential)
Master clock level	Rising edge
Control signal drive	Selectable (TTL or differential)
Control signal level	Programmable (rising or falling)
Minimum control signal pulse width	20 ns
Video data sense	Differential

Usage .....Indoor use only

Clocks

Master clock frequency range.....500 kHz to 40 MHz
(± 0.5% of selected frequency)

Pixel clock frequency range.....500 kHz to 40 MHz

PCI Interface

PCI initiator (master) capability .....Supported

PCI target (slave) capability .....Supported

Data path.....16 bits

Card voltage.....5 V, 12 V, –12 V

Card type.....32-bit half-size card

Parity generation/checking,
error reporting.....Supported

Target decode speed .....Medium (1 clock)

Target fast back-to-back capability .....Supported

Resource locking .....Supported as a master and slave

PCI interrupts.....Interrupts passed on
INTA# signal

Base address registers.....BAR0 (16 KB)
BAR1 (64 KB)

Expansion ROM .....4 KB

PCI master performance

- Ideal .....133 Mbytes/s
- Sustained.....100 Mbytes/s

Power Requirements

Voltage ..... +5 VDC (2 A)
+12 VAC (24 mA)
–12 VDC (20 mA)

Physical

Dimensions

PCI-1422 ..... 10.7 by 17.5 cm (4.2 by 6.9 in.)

PXI-1422 ..... 16 by 10 cm (6.3 by 3.0 in.)

Weight

PCI-1422 ..... 0.127 kg (0.28 lb)

PXI-1422 ..... 0.172 kg (0.38 lb)

Environment

Operating temperature ..... 0 to 55 °C

Storage temperature ..... –20 to 70 °C

Humidity ..... 10 to 90% RH, noncondensing

Maximum altitude ..... 2000 m

Pollution degree 2

MTBF ..... 544,562 h at 25 °C

Functional shock (PXI only) ..... MIL-T-28800 E Class 3 (per Section 4.5.5.4.1) Half-sine shock pulse, 11 ms duration, 30 g peak, 30 shocks per face

Operational random vibration (PXI only) ..... 5 to 500 Hz, 0.31 grms, 3 axes

Nonoperational random vibration (PXI only) ..... 5 to 500 Hz, 2.5 grms, 3 axes

Note Random vibration profiles were developed in accordance with MIL-T-28800E and MIL-STD-810E Method 514. Test levels exceed those recommended in MIL-STD-810E for Category 1 (Basic Transportation, Figures 514.4-1 through 514.4-3).

Electromagnetic Compatibility

EMC/EMI .....CE, C-Tick, and FCC Part 15 (Class A) Compliant

Electrical emissions .....EN 55011 Class A at 10 meters
FCC Part 15A above 1 GHz

Electrical immunity .....Evaluated to EN 61326:1997/ A1:1998, Table 1

Note For full EMC compliance, you must operate this device with shielded cabling. In addition, all covers and filler panels must be installed. See the Declaration of Conformity (DoC) for this product for any additional regulatory compliance information. To obtain the DoC for this product, click **Declaration of Conformity** at `ni.com/hardref.nsf/`. This Web site lists the DoCs by product family. Select the appropriate product family, followed by your product, and a link to the DoC (in Adobe Acrobat format) appears. Click the Acrobat icon to download or read the DoC.

Safety

Meets the requirements of the following standards for safety for electrical equipment for measurement, control, and laboratory use:

EN 61010-1:1993/A2:1995, IEC 61010-1:1990/A2:1995
UL 3101-1:1993, UL 3111-1:1994, UL 3121:1998
CAN/CSA C22.2 no. 1010.1:1992/A2:1997

Installation category I

B

Technical Support Resources

Web Support

National Instruments Web support is your first stop for help in solving installation, configuration, and application problems and questions. Online problem-solving and diagnostic resources include frequently asked questions, knowledge bases, product-specific troubleshooting wizards, manuals, drivers, software updates, and more. Web support is available through the Technical Support section of `ni.com`.

NI Developer Zone

The NI Developer Zone at `ni.com/zone` is the essential resource for building measurement and automation systems. At the NI Developer Zone, you can easily access the latest example programs, system configurators, tutorials, technical news, as well as a community of developers ready to share their own techniques.

Customer Education

National Instruments provides a number of alternatives to satisfy your training needs, from self-paced tutorials, videos, and interactive CDs to instructor-led hands-on courses at locations around the world. Visit the Customer Education section of `ni.com` for online course schedules, syllabi, training centers, and class registration.

System Integration

If you have time constraints, limited in-house technical resources, or other dilemmas, you may prefer to employ consulting or system integration services. You can rely on the expertise available through our worldwide network of Alliance Program members. To find out more about our Alliance system integration solutions, visit the System Integration section of `ni.com`.

Worldwide Support

National Instruments has offices located around the world to help address your support needs. You can access our branch office Web sites from the Worldwide Offices section of `ni.com`. Branch office Web sites provide up-to-date contact information, support phone numbers, e-mail addresses, and current events.

If you have searched the technical support resources on our Web site and still cannot find the answers you need, contact your local office or National Instruments corporate. Phone numbers for our worldwide offices are listed at the front of this manual.

Glossary

Prefix	Meaning	Value
p-	pico-	10^{-12}
n-	nano-	10^{-9}
µ-	micro-	10^{-6}
m-	milli-	10^{-3}
k-	kilo-	10^{3}
M-	mega-	10^{6}
G-	giga-	10^{9}
t-	tera-	10^{12}

Numbers/Symbols

%	Percent.
+	Positive of, or plus.
/	Per.
Ω	Ohm.
±	Plus or minus.
–	Negative of, or minus.

A

A	Amperes.
AC	Alternating current.
acquisition window	The image size specific to a video standard or camera resolution.

active line region	The region of lines actively being stored. Defined by a line start (relative to the vertical synchronization signal) and a line count.
active pixel region	The region of pixels actively being stored. Defined by a pixel start (relative to the horizontal synchronization signal) and a pixel count.
address	Value that identifies a specific location (or series of locations) in memory.
ANSI	American National Standards Institute.
API	Application programming interface.
area	A rectangular portion of an acquisition window or frame that is controlled and defined by software.
array	Ordered, indexed set of data elements of the same type.
ASIC	Application-Specific Integrated Circuit. A proprietary semiconductor component designed and manufactured to perform a set of specific functions for specific customer needs.

B

b	Bit. One binary digit, either 0 or 1.
B	Byte. Eight related bits of data, an eight-bit binary number; also used to denote the amount of memory required to store one byte of data
buffer	Temporary storage for acquired data.
bus	A group of conductors that interconnect individual circuitry in a computer, such as the PCI bus; typically the expansion vehicle to which I/O or other devices are connected.

C

C	Celsius.
cache	High-speed processor memory that buffers commonly used instructions or data to increase processing throughput.
CMOS	Complementary metal-oxide semiconductor.

Compact PCI	Refers to the core specification defined by the PCI Industrial Computer Manufacturer's Group (PICMG).
conversion device	Device that transforms a signal from one form to another. For example, analog-to-digital converters (ADCs) for analog input and digital-to-analog converters (DACs) for analog output.
CPU	Central processing unit.

D

DAQ	Data acquisition. (1) Collecting and measuring electrical signals from sensors, transducers, and test probes or fixtures and inputting them to a computer for processing. (2) Collecting and measuring the same kinds of electrical signals with A/D or DIO boards plugged into a computer, and possibly generating control signals with D/A and/or DIO boards in the same computer.
dB	Decibel. The unit for expressing a logarithmic measure of the ratio of two signal levels: $dB = 20\log_{10} V1/V2$, for signals in volts.
DC	Direct current.
default setting	A default parameter value recorded in the driver; in many cases, the default input of a control is a certain value (often 0) that means *use the current default setting*.
DIN	Deutsche Industrie Norme. A format for electrical connectors.
DMA	Direct memory access. A method by which data can be transferred to and from computer memory from and to a device or memory on the bus while the processor does something else; DMA is the fastest method of transferring data to/from computer memory.
DRAM	Dynamic RAM.
drivers	Software that controls a specific hardware device, such as an image acquisition board.
dynamic range	The ratio of the largest signal level a circuit can handle to the smallest signal level it can handle (usually taken to be the noise level), normally expressed in decibels.

E

EEPROM	Electrically erasable programmable read-only memory. ROM that can be erased with an electrical signal and reprogrammed.
external trigger	A voltage pulse from an external source that triggers an event such as A/D conversion.

F

field	For an interlaced video signal, a field is half the number of horizontal lines needed to represent a frame of video. The first field of a frame contains all the odd-numbered lines, the second field contains all of the even-numbered lines.
FIFO	First-in first-out memory buffer. The first data stored is the first data sent to the acceptor; FIFOs are used on IMAQ devices to temporarily store incoming data until that data can be retrieved.
frame	A complete image. In interlaced formats, a frame is composed of two fields.
ft	Feet.

H

h	Hour.
hue	Represents the dominant color of a pixel. The hue function is a continuous function that covers all the possible colors generated using the R, G, and B primaries. *See also* RGB.
Hz	Hertz. Frequency in units of 1/second.

I

I/O	Input/output. The transfer of data to/from a computer system involving communications channels, operator interface devices, and/or data acquisition and control interfaces.
IC	Integrated circuit.

IEEE	Institute of Electrical and Electronics Engineers.
in.	Inches.
instrument driver	A set of high-level software functions, such as NI-IMAQ, that control specific plug-in computer boards. Instrument drivers are available in several forms, ranging from a function callable from a programming language to a virtual instrument (VI) in LabVIEW.
interlaced	A video frame composed of two interleaved fields. The number of lines in a field are half the number of lines in an interlaced frame.
interrupt	A computer signal indicating that the CPU should suspend its current task to service a designated activity.
interrupt level	The relative priority at which a device can interrupt.
IRQ	Interrupt request. *See* interrupt.

K

k	Kilo. The standard metric prefix for 1,000, or 10^3, used with units of measure such as volts, hertz, and meters.
K	Kilo. The prefix for 1,024, or 2^{10}, used with B in quantifying data or computer memory.
kbytes/s	A unit for data transfer that means 1,000 or 10^3 bytes/s.
Kword	1,024 words of memory.

L

line count	The total number of horizontal lines in the picture.
LSB	Least significant bit.
LUT	Lookup table. Table containing values used to transform the gray-level values of an image. For each gray-level value in the image, the corresponding new value is obtained from the look-up table.

M

m	Meters.
M	(1) Mega, the standard metric prefix for 1 million or 10^6, when used with units of measure such as volts and hertz; (2) mega, the prefix for 1,048,576, or 2^{20}, when used with B to quantify data or computer memory.
MB	Megabyte of memory.
Mbytes/s	A unit for data transfer that means 1 million or 10^6 bytes/s.
memory buffer	*See* buffer.
memory window	Continuous blocks of memory that can be accessed quickly by changing addresses on the local processor.
MSB	Most significant bit.
MTBF	Mean time between failure.
mux	Multiplexer. A switching device with multiple inputs that selectively connects one of its inputs to its output.

N

NI-IMAQ	Driver software for National Instruments IMAQ hardware.
noninterlaced	A video frame where all the lines are scanned sequentially, instead of divided into two frames as in an interlaced video frame.
NVRAM	Nonvolatile RAM. RAM that is not erased when a device loses power or is turned off.

O

operating system	Base-level software that controls a computer, runs programs, interacts with users, and communicates with installed hardware or peripheral devices.

P

PAL	Phase Alternation Line. One of the European video color standards; uses 625 lines per frame. *See also* NTSC.
PCI	Peripheral Component Interconnect. A high-performance expansion bus architecture originally developed by Intel to replace ISA and EISA. PCI offers a theoretical maximum transfer rate of 132 Mbytes/s.
PFI	Programmable function input.
PGIA	Programmable gain instrumentation amplifier.
pixel	Picture element. The smallest division that makes up the video scan line; for display on a computer monitor, a pixel's optimum dimension is square (aspect ratio of 1:1, or the width equal to the height).
pixel clock	Divides the incoming horizontal video line into pixels.
pixel count	The total number of pixels between two horizontal synchronization signals. The pixel count determines the frequency of the pixel clock.
protocol	The exact sequence of bits, characters, and control codes used to transfer data between computers and peripherals through a communications channel.
pts	Points.
PXI	PCI eXtensions for Instrumentation. An open specification that builds on the CompactPCI specification by adding instrumentation-specific features.

R

RAM	Random-access memory.
real time	A property of an event or system in which data is processed as it is acquired instead of being accumulated and processed at a later time.
resolution	The smallest signal increment that can be detected by a measurement system. Resolution can be expressed in bits, in proportions, or in percent of full scale. For example, a system has 12-bit resolution, one part in 4,096 resolution, and 0.0244 percent of full scale.

RGB	Color encoding scheme using red, green, and blue (RGB) color information where each pixel in the color image is encoded using 32 bits: 8 bits for red, 8 bits for green, 8 bits for blue, and 8 bits for the alpha value (unused).
ribbon cable	A flat cable in which the conductors are side by side.
ROI	Region of interest. A hardware-programmable rectangular portion of the acquisition window.
ROM	Read-only memory.
RTSI bus	Real-Time System Integration Bus. The National Instruments timing bus that connects IMAQ and DAQ boards directly, by means of connectors on top of the boards, for precise synchronization of functions.

S

s	Seconds.
scaling down circuitry	Circuitry that scales down the resolution of a video signal.
scatter-gather DMA	A type of DMA that allows the DMA controller to reconfigure on-the-fly.
SDRAM	Synchronous dynamic RAM.
SO-DIMM	Small outline dual inline memory module.
SRAM	Static RAM.
system RAM	RAM installed on a personal computer and used by the operating system, as contrasted with onboard RAM.

T

tap	A stream of pixels from a camera. Some cameras send multiple streams, or taps, of data over a cable simultaneously to increase transfer rate.
transfer rate	The rate, measured in bytes/s, at which data is moved from source to destination after software initialization and set up operations. The maximum rate at which the hardware can operate.
trigger	Any event that causes or starts some form of data capture.

trigger control and mapping circuitry	Circuitry that routes, monitors, and drives external and RTSI bus trigger lines. You can configure each of these lines to start or stop acquisition on a rising or falling edge.
TTL	Transistor-transistor logic.

V

VI	Virtual Instrument. (1) A combination of hardware and/or software elements, typically used with a PC, that has the functionality of a classic stand-alone instrument (2) A LabVIEW software module (VI), which consists of a front panel user interface and a block diagram program.

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